Title: Investigating Nitric Oxide Production by Lightning using fully-coupled Radiation Transport, Hydrodynamics and Chemistry

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Abstract: Numerical simulations [Goldenbaum & Dickerson, JGR, 1993] and laboratory experiments [Navarro-González et al., GRL, 2001] indicate that nitric oxide (NO) is produced in the high temperature lightning return-stroke channel. As the channel temperature and density drop, a "freeze-out" point is reached where the reactions that produce and destroy NO become too slow to further alter the ambient NO concentration. Exactly when and why this freeze-out point occurs is a matter of concern and debate. Goldbenbaum & Dickerson, using a purely hydrodynamic modeled with 18 chemical reactions, find that after a few microseconds a rapid drop in channel air density triggers the freeze-out. This finding is in opposition to the phenomenological models of Borucki and Chameides [RGSP, 1984] and Bhetanabhotla et al. [AE, 1985] which invoke a slower temperature decay—driven by turbulent and radiative cooling—to arrive at temperature driven freeze-out that occurs after hundreds of microseconds of channel evolution.

In this talk, we present results from a new model of the lightning return-stroke channel that incorporates fully-coupled radiation transport, hydrodynamics and chemistry. Our model extends the work of Goldenbaum & Dickerson in the following important ways: (i) we include a multispectral dynamical equation for radiation that is directly coupled to the local concentration and radiative properties of chemical species, (ii) a total of 687 chemical reactions are modeled including the important NO self-destruction reaction $NO + NO \rightarrow N_2O + O$ and (iii) we use an eddy-diffusivity model to incorporate the effects of turbulent mixing. Using our fully-coupled dynamical model we revisit the origin and nature of NO freeze-out during the complex evolution of the return-stroke channel.